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A. T. MASTERMAN, D. Sc.
INSPECTOR OF FISHERIES, ENGLAND

MEMORANDUM ON THE VITALITY OF TRAWL-CAUGHT-FISH

EN COMMISSION CHEZ
ANDR. FRED. HØST & FILS
COPENHAGUE

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MEMORANDUM
ON THE VITALITY OF TRAWL-CAUGHT FISH

BY

A. T. MASTERMAN, D. Sc.

Inspector of Fisheries, England

The question of the vitality of trawl-caught fish is of the greatest importance from the point of view of fishery legislation.

Amongst other details of information which are required are these:

1. What proportion of fish are mortally injured in the ordinary process of commercial trawling?
2. At what stages in the process are the greater proportion of such fish injured?
3. Can the injuries be in any way avoided by a modification in appliances?

The theory which is most generally held is that all or nearly all the fish, especially small fish, are dead or dying when brought on board, at least in the case of the large steam trawlers, — owing as it is said to the prolonged pressure of fish in the cod-end. Others have maintained that many are alive when brought on board but perish during the "sorting" operations, so that, they are dead by the time they are shovelled overboard.

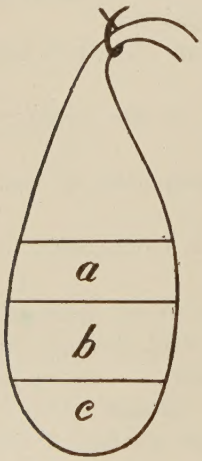
In a preliminary attempt to investigate, or to see how far it was possible to investigate, this subject I visited the Horn Reef grounds in July, 1907, for four or five days. I was indepted to the hospitality of the Royal National Mission to Deep Sea Fishermen and to the kindly assistance of the skipper of the S/S "Alpha", which trawls regularly with the Gamecock Fleet.

Conditions of Trawling

The usual length of haul is 8 hours but on occasions it may be shortened to 6 or 5 hours, according to the nature of the ground. The rate of trawling is also varied from two to three knots. The headline of the trawl of the "Alpha" was about 93 feet. During the period of hauling, the fish are swept into the net but do not by any means all pass into the cod-end.

It is during the process of hauling in the net that the fish are shaken by degrees downwards towards the extreme cod-end. A bight of rope is then put round the neck of the cod-end and the whole is hoisted over the gunwale and suspended two feet above the deck. The great mass of fish presses out in all directions and many fish are forced through the meshes in a distorted or mutilated condition. The fish form an enormous globular mass one ton or more in weight and remain suspended in this manner for some considerable time till the bulk of the water is run off. The tie of rope closing the cod-end is then slipped and the fish fall into the deck trough.

Both from *a priori* reasoning and as a result of the experiments it can be maintained that the fish sustain comparatively little injury during the trawling operations but are undoubtedly killed and injured in large quantities in the process of "shipping". In our recent work upon the plaice we have determined the specific gravity of this fish to vary between the extreme limits of 1·09 and 1·05 taking ordinary fresh-water at 9° c—10° c as the unit. The specific gravity of sea-water in the North-Sea may be taken roughly as 1·02—1·04. It is therefore clear that fish like the plaice have a weight in sea-water which is practically negligible. Any pressure to which the fish are subjected whilst the trawl is "down" must therefore be caused by the force of water moving at 2 to 3 knots per hour through the net. A current of 2 to 3 knots per hour cannot be regarded as of any great importance as affecting the locomotion of the plaice. We must suppose that at such a pace the fish are largely free to move about inside the net and that their respiration would not be likely to be interfered with. Experiments with samples of fish taken from the net before "shipping" would determine this question.



As soon, however, as the fish are shaken together and lifted out of the water their weight becomes slightly greater than that of an equal body of water.

The fish may be regarded as being distributed in three layers:

There are those at the top of the cod-end (a) which are more or less free to kick and are hardly affected by pressure: in the middle (b) are those which are packed together fairly closely and subjected to a considerable pressure: at the bottom (c) are those which are compressed tightly by the weight above them. Many of these are actually killed *in situ* and no doubt others are mortally injured. It is evident that the pressures will not be distributed thus in regular

vertical direction but in accordance with the laws of pressure in a more or less spherical mass. This, however, hardly affects the main point.

When the fish are discharged into the deck troughs, the injured (c) fish tend to fall out first and those which are least injured (a) are left leaping about on the top of the mass of fish.

The sorting is begun at once and lasts for from one to two hours, according to the extent of the catch.

A large number of the unmarketable fish are picked out as they are reached in sorting and these are thrown overboard, and finally the remainder are shovelled over in the clean-up.

I experimented with samples of these fish and those of a larger size, selected from the top, the middle and the last part of the catch, and the general result appears to be that the first are practically all and alive normal, the second vary in their percentage of injured and the third are nearly all dead or dying.

From the above remarks, it will be seen that there are two co-operating factors which conduce to this result. Firstly, the varying pressure in the cod-end and secondly, the length of exposure on deck, to which may be added the injuries effected by the boots of the men. To determine which of these factors is the more potent, it would be necessary to take immediate samples of (a), (b) and (c) when the fish are discharged. So far as my information goes, I am inclined to ascribe the greatest injury to the pressure in the cod-end.

Procedure of Experiments

Samples of plaice were taken from the trough at various stages of the sorting process and were transferred into large bath-tubs with a continuous supply of sea-water. It was found that the number and size of the available tubs limited the experiment, and the plaice lying over each other did not have a full chance of recovery. In the last experiment a kind of cage made of wire-netting was constructed. This was let down overboard into the sea and the fish were placed in it. The effect of the open water was very marked in restoring the fish. Its use was limited to the last haul of each boarding as it was not workable when the steamer was in motion. It is important that in any future experiments some such a device as this should be employed.

The details of the experiments are given in the accompanying table. There are four samples of fish from the top of the mass, taken from different hauls. Out of a total of 105 fish, 94 were still alive after half-an-hour in the tubs of water. After a lapse of one hour they were reduced to 87 and at the end of two hours they were still further reduced to 70 or 66 % of the original total.

Date	Part of haul sampled	No. of fish	No. of fish alive		
			1/2 hour	1 hour	2 hours
25. VII. 5 a. m. . . .	Top	34	34	34	17
25. VII. 4 p. m. . . .	Top	30	28	25	25
— . . .	Middle (after 1/2 hour)	25	13	12	9
— . . .	Bottom mostly dead or injured (after 1 1/2 hours)	10 (Selected)	10	5	3
26. VII. 4 p. m. . . .	Top	16	16	15	15
— . . .	Middle (after 3/4 hour)	20	14	10	10
— . . .	Bottom (after 1 1/2 hours)	12	6	4	3
27. VII. 5 a. m. . . .	Top	25	16	13	[1]
— . . .	Middle (after exposure 1/2 hour)	35	20	13	[1]

[1]) All recovered after placing in the cage.

The average mortality was therefore 34 % and varied from 50 % in the first experiment to only about 7 % in the third. The high mortality of the first experiment may be due partly in the insufficient æration provided. A larger quantity of fish was taken and they were all alive at the end of one hour.

Three samples were taken from the middle of the mass, from different hauls, after the lapse of from 1/2 to 3/4 of an hour from the commencement of sorting. The total number of fish taken was 80 and of these 47 were alive after 1/2 an hour in water, 35 after 1 hour and 32 at the end of two hours. The average mortality after two hours was therefore 60 %, varying from 64 % to 50 %.

These fish had been subjected to greater pressure and to a longer exposure than the first samples; it cannot be said with certainty which of these two factors is the more potent in raising the death-rate.

Two samples were taken from the fish at the end of sorting. These fish had lain on deck, more or less covered by others, for about 1 1/2 hours before they were returned to water. The total was 22 fish of which 16 were alive after 1/2 an hour, 9 after one hour, and only 6 at the end of two hours. The average mortality after two hours was 73 %.

Throughout the experiments, only live fish were selected, and, as the proportion of dead to live fish is continually increasing in the main mass of fish as sorting proceeds, it is clear that the percentage death-rates given by these experiments have to be increased by some unknown factor to represent the true mortality. Experiments with the whole catch of certain hauls are necessary to determine this point.

In any case, the experiments here described have been conducted on too small a scale to permit of definite conclusions. Any value attaching to them consists in the demonstration that it is possible to make use of commercial trawlers for experimental work without interfering with the normal course of preceedings and thus to ascertain a knowledge of the precise conditions under which fish is caught for commercial purposes.

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a paru en Janvier 1907. Elle est envoyée **franco**, sur demande adressée à MM. **Andr. Fred. Høst et fils,** libraires à Copenhague.

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